COMPUTER-BASED SIMULATION OF IOL INJECTION: TOWARD A FULL FEATURED CATARACT SURGERY TRAINING SYSTEM

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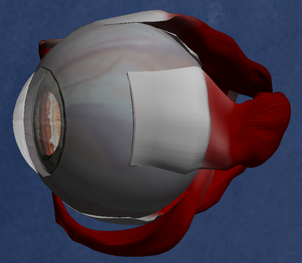
PURPOSE

Cataract surgery is one of the most frequently performed procedures in the world. Current methods of training are based on companionship and expose potentially patients to complications inherent to the inexperience of the operator. Recently, several reports have demonstrated the validity and added value of computer-based training systems. These different motivations led us to develop a computer-based cataract surgery simulator that could offer a new way of learning for young ophthalmologists. The work presented here focuses on intra-ocular lens modeling and its deployment within the lens capsule, a stage of cataract surgery that has never been addressed before in a simulation system.

MATERIAL AND METHOD

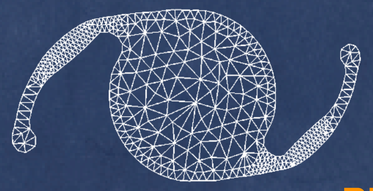
ANATOMICAL MODELS

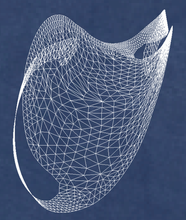
For the purpose of the simulation, we have developed two types of models
- anatomical models of the main structures of the human eye (sclerotic, conjunctiva, cornea, retina...), that provide the visual background of our simulation
- dynamic, physical models of the structures manipulated during the simulated procedure (lens, capsule, intra ocular lens)



PHYSICAL MODELS

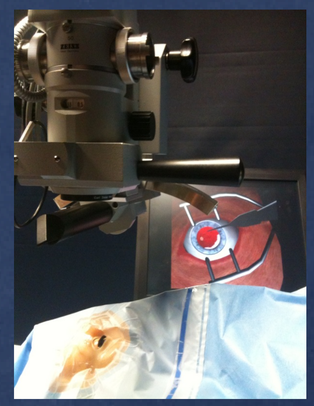
The dynamic behavior of the structures is simulated using the finite element method which requires a discretization of the geometry and knowledge of the physical characteristics of these structures. Accuracy and computation time depend on the level of discretization. We have developed specific algorithms and computational models that allow real-time simulations without sacrificing realism. Interactions between the eye, the instruments and the intra-ocular lens are based on a constraints method.





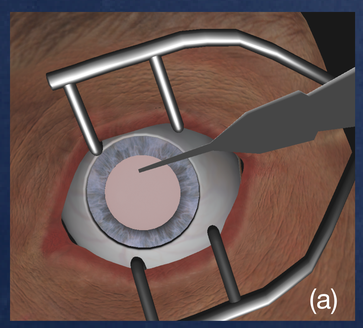
TRAINING SYSTEM

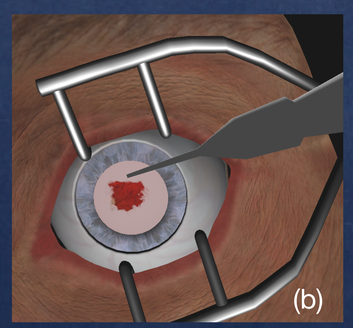
Our simulator consists of a computer for calculations and visual rendering and input devices allowing inter-actions with a virtual environment. Among the available interfaces is a tracking system that transmits the position of mock instruments. The overall simulation system includes a whole body mannequin with an instrumented head and simulated physiology, as well as a refurbished Zeiss microscope for added realism.

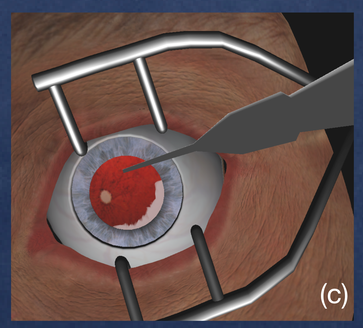


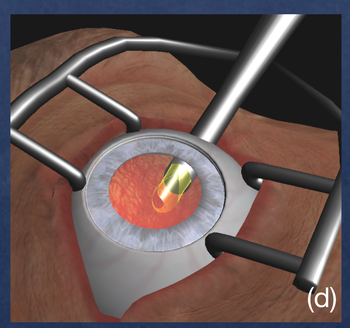
RESULTS

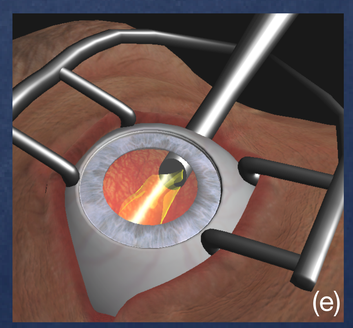
We have simulated the main stages of cataract surgery, namely: capsulorhexis, phacofragmentation and aspiration of the fragments, injection of the lens and its deployment in the capsule. Figures (a), (b), (c) illustrate different steps of the phacoemulsification stage, and figures (d), (e) and (f) show the simulated injection of the intra-ocular lens.

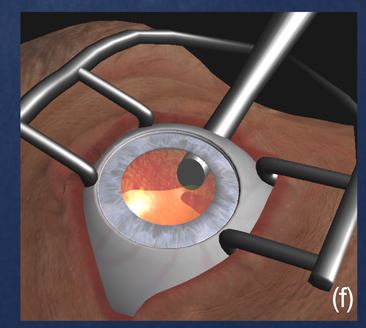












DISCUSSION

This work is a collaboration between clinicians and researchers and our first results are promising. Each of the previous stages has been tested and the next step will be to validate the simulation in its entirety. We are still working on the interaction model to improve realism and obtain a real time simulation.

CONCLUSION

We have simulated the main stages of cataract surgery and realistic training conditions can be obtained thanks to our mock up surgical unit. The outcome of this work will offer an alternative surgery teaching for resident in training. We plan to include the simulation of complications and define validation metrics.

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